APPLICATION FOR UNITED STATES LETTERS PATENT

APPARATUS AND METHOD
FOR
A DATA INPUT DEVICE USING A LIGHT LAMINA SCREEN
AND AN OPTICAL POSITION DIGITIZER

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CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of priority under 35 U.S.C. § 119(e) to U.S. Provisional Application No. 60/461,045, filed April 08, 2003, entitled OPTICAL POSITION DIGITIZER WITH INPUT LIGHT LAMINA, which is incorporated herein by reference in its entireties and for all purposes.

BACKGROUND OF THE INVENTION

1.   FIELD OF THE INVENTION

[0002] The present invention relates generally to data input devices, and more particularly, to a continuous sheet or "lamina" of light provided in the free space adjacent a touch screen and to an optical position digitizer that detects data entries by determining the location of "shadows" in the lamina caused by an input device, such as a finger or a stylus, interrupting the lamina when contacting the screen during a data entry operation.

2.   DESCRIPTION OF THE RELATED ART

[0003] User input devices for data processing systems can take many forms. Two types of relevance are touch screens and pen-based screens. With either a touch screen or a pen-based screen, a user may input data by touching the display screen with either a finger or an input device such as a stylus or pen.

[0004] One conventional approach to providing a touch or pen-based input system is to overlay a resistive or capacitive film over the display screen. This approach has a number of problems. Foremost, the film causes the display to appear dim and obscures viewing of the underlying display. To compensate, the intensity of the display screen is often increased. However, in the case of most portable devices, such as cell phones, personal

digital assistants, and laptop computers, high intensity screens are usually not provided. If they were available, the added intensity would require additional power, reducing the life of the battery of the device before recharge. The films are also easily damaged. In addition, the cost of the film scales dramatically with the size of the screen. With large screens, the cost is therefore typically prohibitive.

[0005] Another approach to providing touch or pen-based input systems is to use an array of source Light Emitting Diodes (LEDs) along two adjacent X-Y sides of an input display and a reciprocal array of corresponding photodiodes along the opposite two adjacent X-Y sides of the input display. Each LED generates a light beam directed to the reciprocal photodiode. When the user touches the display, with either a finger or pen, the interruptions in the light beams are detected by the corresponding X and Y photodiodes on the opposite side of the display. The data input is thus determined by calculating the coordinates of the interruption of the light beams as detected by the X and Y photodiodes. This type of data input display, however, also has a number of problems. A large number of LEDs and photodiodes are required for a typical data input display. The position of the LEDs and the reciprocal photodiodes also need to be aligned. The relatively large number of LEDs and photodiodes, and the need for precise alignment, make such displays complex, expensive, and difficult to manufacture.

[0006] Accordingly, there is a need for a data entry apparatus and method having a continuous sheet or "lamina" of light provided in the free space adjacent a touch screen and to an optical position digitizer that detects data entries by determining the location of "shadows" in the lamina caused by an input device, such as a finger or a stylus, interrupting the lamina when contacting the screen during a data entry operation.

SUMMARY OF THE INVENTION

[0007] The present invention relates to a data entry apparatus and method. The data entry apparatus has a continuous sheet or "lamina" of light in the free space adjacent a touch screen. An optical position detection device, optically coupled to the lamina of light, is provided to detect data entries to the input device by determining the location of interrupts in the lamina caused when data is entered to the input device. During the method of operation, a user makes a data entry to the device by touching the screen using an input device, such as a finger, pen or stylus. During the act of touching the screen, the lamina of light in the free space adjacent the screen is interrupted. The optical position detection device detects the position of the input based on the location of the interrupt. Based on the determined position, the data entry is determined.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] The invention, together with further advantages thereof, may best be understood by reference to the following description taken in conjunction with the accompanying drawings in which:

[0009] Figure 1 is a touch screen display according to the present invention.

[0010] Figure 2 is a light receiving element used in one embodiment of the present invention.

[0011] Figures 3A – 3C are a series of diagrams illustrating .the decoding of data entries and interrupt shadow interpolation according to one embodiment of the present invention.

[0012] In the figures, like reference numbers refer to like components and elements.

DETAILED DESCRIPTION OF THE INVENTION

[0013] Referring to Figure 1, a touch screen display system according to one embodiment of the present invention is shown. The touch screen display system 10 includes a continuous plane or "lamina" 12 of light generated in the free space adjacent to or just above a display screen 14. The lamina 12 is generated by an X axis input light source 16 and a Y axis input light source 18, each configured to propagate light across the free space immediately above the surface of the screen 14 in the X and Y directions respectively. The free space is generally parallel to the surface of the screen 14 and is positioned just in front of the screen 14. The lamina 12 is thus interrupted when an input device (not shown), such as a user's finger or a hand-held stylus or pen, is used to touch the screen 14 during a data entry operation. An X axis light receiving array 20 and a Y axis light receiving array 22 are positioned on the two opposing sides of the screen 14 opposite the X axis and Y axis light sources 16 and 18 respectively. The light receiving arrays 20 and 22 detect the X axis and Y axis coordinates of any interrupt or " shadow" in the lamina 12, caused by an input device breaking the lamina 12 in the free space above the screen 14 during a data entry operation. A processor 24, coupled to the X axis and Y axis arrays 20 and 22, is used to calculate the X axis and Y axis coordinates of the interrupt. Together, the X and Y axis arrays 20 and 22 and the processor 24 provide an optical position detection device for detecting the position of interrupts in the lamina 12. Based on the coordinates of the interrupt, a data entry on the screen 14 can be determined.

[0014] The light lamina 12 is substantially of uniform intensity according to one embodiment of the invention. The required dynamic range of the photosensitive circuitry in the receiving X axis and Y axis arrays 20 and 22 is therefore minimized and high interpolation accuracy is maintained. In an alternative embodiment, however, a non-uniform lamina 12 may be used. In this circumstance, the lowest intensity area of the lamina 12 should be higher than the light activation threshold of the light detecting elements used by the X axis and Y axis arrays 20 and 22.

[0015] The display screen 14 can be any type of data display according to various embodiments of the invention. For example, the screen 14 can be a display for a personal computer, workstation, server, mobile computer, laptop computer, a point of sale

5

terminal, personal digital assistance (PDA), cell phone, any combination thereof, or any type of device that receives and processes data entries.

[0016] The X and Y input light sources 16 and 18 are each a source of collimated light beams according to one embodiment of the invention. The collimated light may be generated in any of a number of different ways. For example, from a single light source mounted at the focal point of a collimating lens. Alternatively, the collimated light beams may be generated from a plurality of point light sources and collimated lenses respectively. In yet another embodiment, the X and Y input light sources 16 and 18 can be made from a fluorescent light and a diffuser. The point light source or sources may be a Light Emitting Diode (LED) or a Vertical Cavity Surface Emitting Laser (VCSEL).

[0017] In yet another embodiment, the light source may be a light transmitter with spaced facets fed by a vertical laser. For more details on this embodiment, see U.S. Patent Application No. Serial No. (to be determined / Attorney Docket No. NSC1P307) entitled Apparatus and Method for Generating Parallel Beams of Light" by David Graham, co-inventor of the subject application and assigned to the assignee of the present application, filed on the same day as the present application, and incorporated by reference herein for all purposes.

[0018] The wavelength of the light generated by the X axis and Y axis light sources 16 and 18 used to create the lamina 12 may also vary according to different embodiments of the invention. For example, the light may be of a wide-band having an extended wavelength spectrum range from 350 nanometers to 1100 nanometers, such as white light from an incandescent source. Alternatively, the input light can be of a narrow band having a limited spectrum ranging within 2 nanometers. The use of narrow band light enables the filtering of wide band ambient noise light. The use of narrow band light also enables the substantial matching of the light wavelength to the response profile of the X axis light receiving array 20 and the Y axis light receiving array 22. In yet another embodiment, a homogeneous, single wavelength light, may be used. For example infrared or IR light, commonly used in wireless or remote data transfer communications, may be used in this application.

[0019] The light sources, regardless of the type, may also be operated either continuously or periodically, using on an on/off cycle. An on/off cycle conserves power, minimizes the

heat generated by the source light, and permits temporal filtering to reduce noise, such as lock in detection. During the off cycle, the X light receiving array 20 and a Y light receiving array 22 measure the passive or "dark" light (noise). The dark light measurement is then subtracted from the active light detected during the on cycle. The subtraction thus filters out DC background caused by the ambient light. During each off cycle, the passive light may also be calibrated, permitting the system to adjust to changing ambient light patterns.

[0020] In yet another embodiment, the X axis and Y axis light sources 16 and 18 may be cycled on and off intermittently. During alternate cycles, when the X axis source 16 is on, the Y axis source 18 is off, and vice versa. This arrangement requires less peak power since only one light source is on at a time, while still allowing subtraction filtering to occur during each X and Yon/off cycle respectively.

[0021] To reduce power consumption, a "sleep" mode may also be used for the X axis and Y axis light sources 16 and 18. If no data inputs are made for a predetermined period of time, the intensity of the X axis and Y axis light sources 16 and 18 may be dimmed. The rate at which shadow interrupts are sampled is also done at a low rate, for example, approximately 5 times a second. When a shadow interrupt is detected, the intensity of the X axis and Y axis light sources 16 and 18 and the sampling rate are all increased to a normal operating mode. If no shadow interrupts are detected after the predetermined period of time, X axis and Y axis light sources 16 and 18 are again dimmed and the sampling rate reduced.

[0022] The X axis and Y axis arrays 20 and 22 each include substrate waveguide arrays and photosensitive elements. The photosensitive elements are configured to convert light signals into electrical signals indicative of the intensity of the received light. Specifically, each substrate has a plurality of waveguides. Each waveguide has a free space end proximate the lamina 12 and an output end proximate to a photosensitive element. The photosensitive elements are either affixed to or positioned adjacent the output end of the waveguides respectively. For a detailed explanation of the use and manufacture of waveguides, see US Patent No. 5,914,709 by David Graham et. al., the inventor of the present application, and incorporated by reference herein for all purposes. The photosensitive elements can be implemented using a number of well known ways, for example using Charge-Coupled Devices (CCD) or CMOS/photodiode arrays. Either type

of imaging element can be implemented in many forms, including on a dedicated integrated circuit such as an application specific integrated circuit, a programmable circuit, or any other type of integrated or discrete circuit containing photosensitive areas or components. Again, additional details on the various types of photosensitive elements that may be used with the present invention are discussed in the aforementioned patent. Regardless of the type of photosensitive elements used, the output electrical signals indicative of the received light intensity along the X and Y coordinates are provided to the processor 24. The processor 24 determines the location of any shadows in the lamina, caused by an interrupt in the lamina 12 during an input operation, based on the electrical signals.

[0023] Referring to Figure 2, a light receiving element used in one embodiment of the present invention is shown. Specifically, a section of a waveguide substrate 30 used by the X axis 20 and/or the Y axis array 22 is shown. The waveguide substrate 30 includes a plurality of channels 32. Each channel includes a light input end 34 and a light output end 36. The channels provide incident light from the lamina 12 to the photosensitive elements (not shown) on the array. At the light input end 34, an integral light receiving element 38 is provided. A wavelength filter 39, positioned over the light receiving elements, is also provided. The filter 39 is used to filter out ambient light and allow light having a wavelength substantially matching the response profile of the photosensitive elements. In various embodiments, the filter 39 may be either an absorption filter or an interference filter. For the sake of simplicity, only three channels 32 and light receiving elements 38 are shown in Figure 2. It should be noted that according to one embodiment of the invention, a light receiving elements is provided for each waveguide channel 32 of both the X axis and Y axis arrays 20 and 22 respectively. In alternative embodiments, the light receiving elements may be used for in none or some of the channels 32 in either the X axis and/or Y axis arrays.

[0024] The light receiving element 38 is configured to direct incident lamina light into the light receiving end 34 of each waveguide channel 32 respectively. According to various embodiments, the light receiving elements 38 may be a single lens, a compound lens, or some other type of optical system. In any case, the light receiving elements 38 are configured to collect lamina light and focus it into the light receiving end 34 of each waveguide channel 32 respectively. The light receiving elements 38 thus improve the

signal-to-noise ratio of the photosensitive elements in a number of ways. Foremost, the light receiving elements 38 enable the collection of more lamina light than otherwise possible without the use of lenses or some kind of optical assembly. The collimation of the lamina light also provides directional filtering which further improves the signal-to-noise ration. Lastly, the light receiving elements 38 are helpful in rejecting angle light, ambient light, reflection flare, and diverging or converging light. The rejection of such noise again is helpful in improving the signal-to-noise ratio.

[0025] Referring to Figures 3A-3C, a series of diagrams illustrating the decoding of data entries and interrupt shadow interpolation according to one embodiment of the present invention is shown. In this example, the lamina 12 is made of homogeneous light. Each Figure 3A-3C shows a different location of a shadow interrupt 42a-42c with respect to waveguide channels 32a-32c. The light intensity received by each waveguide channel 32a-32c in each case is represented by an intensity graph 42a-42c respectively. The shadows 40a-40c are created by an input device, such as a finger or stylus, interrupting the lamina 12 when contacting the screen 14. In Figure 3A, the interrupt shadow 40a does not block any of the light receiving element 38a. As a result, the corresponding light intensity 42a is at a full level, indicating that the shadow interrupt 42a is not blocking any of the light of lamina 12 from being received by element 38a. In Figure 3B, the shadow interrupt 40b is blocking approximately half of the light from lamina 12. Consequently the intensity graph 42b is approximately half the full amount. Finally, in Figure 3C, the shadow interrupt 40c is shown completely blocking the light from lamina 12. The intensity level 42c is therefore negligible. Based on the received light intensity values 42a-42c, the location of the interrupt can be interpolated to be at 42c. Interpolation is enhanced by the homogeneity of the lamina. Inhomogeneity in the incident signal is added to the uncertainty in the interpolation.

[0026] The use of a continuous plane of light or lamina 12 thus provides a "registration-free" environment. The X axis and Y axis arrays 20 and 22 detect interruptions in the otherwise continuous plane of lamina light 12, as opposed to interruptions in discrete light beams. Accordingly, the need to align discrete light emitting elements with reciprocal light receiving elements opposite the display is eliminated. The lamina 12 also provides improved shadow interruption detection and interpolation. Finally, the devices

and methods available for generating the lamina 12 are typically more space and power efficient than what is required to generate discrete light beams.

[0027] Although the foregoing invention has been described in some detail for purposes of clarity of understanding, it will be apparent that certain changes and modifications may be practiced within the scope of the appended claims. For example, the present invention has been described with use with a two dimensional (X axis and Y axis) lamina 12. The present invention, however, can be used with either a one dimensional lamina plane (i.e., a line) or even a three dimensional lamina space (X axis, Y axis and Z axis). In any case, the number of light sources and light receiving arrays is generally, but not necessarily, the same as the number of axis used in the system. For example, in the two dimensional lamina 12 illustrated in Figure 1, X axis and Y axis light sources 16 and 18 are used. However, in alternative embodiments, a single axis light source could be used along either the X axis or the Y axis to create the lamina. Therefore, the described embodiments should be taken as illustrative and not restrictive, and the invention should not be limited to the details given herein but should be defined by the following claims and their full scope of equivalents.